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Business model change for products and services based on the Internet of Things: A multiple case study

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Biographic note

Aires Daniel Ramos da Silva was born in 1991 in Porto, Portugal. He graduated from the Porto Accounting and Business School in 2015, with a degree in International Commerce. One year later, he enrolled the Master in Innovation Economics and Management, at the Faculty of Economics (FEP), concluding it with the dissertation entitled: "Business model change for products and services based on the Internet of Things: A multiple case study".

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Resumo

Atualmente, um número crescente de produtos, como telemóveis, aparelhos eletrónicos, eletrodomésticos e automóveis, estão conectados à Internet. Essa conectividade permite com que esses produtos forneçam informações relevantes para monitorização ou controlo remoto, como parte de um propósito útil. A Internet das Coisas (conhecida pela sigla IoT, do Inglês, Internet of Things) é um novo paradigma que engloba as oportunidades de todos esses produtos estarem conectados, e as possíveis interações que eles podem ter uns com os outros, possibilitando aplicações com o intuito de melhorar o dia-a-dia de diferentes maneiras.

Empresas que comercializam produtos e serviços baseados em IoT, desenvolvem os seus modelos de negócio de acordo com as especificidades desse paradigma tecnológico, para se adaptarem ao mercado e serem rentáveis. Na ultima década, a maneira de pensar sobre modelos de negócio mudou, e é cada vez mais relevante examinar modelos de negócio, não como imagens estáticas, mas como conceitos dinâmicos e evolutivos.

Através do uso de um estudo de caso múltiplo, o objetivo deste trabalho é analisar os modelos de negócio de empresas de IoT, como eram inicialmente, e como são hoje, comparando ambos para entender a mudança e evolução que ocorreu, de forma a responder à seguinte questão de investigação: "Como e porquê, empresas baseadas em IoT mudam os seus modelos de negócio?".

Este estudo compreende uma revisão sobre a literatura existente, relativa à mudança e evolução de modelos de negócio, assim como a modelos de negócios já existentes para IoT. São discutidos os principais fatores que podem levar as empresas baseadas em IoT a mudar e evoluir os seus modelos de negócio.

Palavras-chave: Internet das coisas, modelo de negócio, canvas, mudança e evolução

JEL-Codes: M10, M13

Abstract

Presently, a growing number of products, such as smartphones, consumer electronics, appliances and automobiles, include connectivity to the Internet. This connectivity enables those products to provide relevant information for monitoring or being remotely controlled, as part of some useful purpose. The Internet of Things (IoT) is a new paradigm that looks into the opportunities of all these products being connected, and interactions they can have with each other, enabling endless possibilities and enhancing everyday life in different ways.

Companies that commercialize products and services based on the IoT, develop their business models according to the specificities of this technological paradigm, in order to adapt themselves to the market and be profitable. In the past decade, the way of thinking about business models has changed, and it is becoming more relevant to look into business models not as static pictures, but as dynamic and evolutive concepts.

Through the use of a multiple-case study, the purpose of this work is to analyse IoT companies' business models, as they were on their initial stage and as they are at the present day, comparing both in order to understand the change and evolution they have gone through, so it answers to the following research question "How and why do IoT-based companies change their business models?".

This study provides further insights on the existing literature regarding the business models change and evolution, and the already existing business models for IoT. It discusses the main factors that can lead IoT-based companies to change and evolve their business models.

Keywords: Internet of things, business model, canvas, change and evolution

JEL-Codes: M10, M13

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List of abbreviations

BM – Business Model

CEO – Chief Executive Officer

IoT – Internet of Things

IT – Information Technology

RFID – Radio-Frequency Identification

SME – Small and Medium Enterprise

1. Introduction

Presently, companies are part of a highly dynamic business environment, driven by rapid technological developments where the digital wave is pushing itself inside non digital products, such as bicycles, clothes and house appliances (Turber & Smiela, 2014). This technological paradigm is called Internet of Things (henceforth IoT) and is expected to significantly impact products and services, as well as the business models of companies that commercialize such products and services (Turber, Brocke, Gassmann, & Fleisch, 2014).

The IoT became a major technological trend and is considered by a large group of technological companies' CEOs as one important focus of technological evolution, therefore being important to the current technological picture (Berman, Davidson, Ikeda, Korsten, & Marshall, 2016). In 2013, there were around 5 billion things connected to the Internet (Chase, 2013). This number has been increasing since then, and it is expected to reach 50 billion by the year of 2020 (Gurpreet, Cheema, & Kapoor, 2017). The IoT enabled new ways of communication between people and things (products), and between things themselves, thus creating a new dimension to the world of information and communication (Bandyopadhyay & Sen, 2011). It is expected that the IoT will somehow change the way we live: from factory automation, to wearable sensors and home appliances, there will be networks of things around us, changing and working based on our surrounding and sensor inputs, with endless possibilities that can impact positively areas such as safety, health and environment (Chase, 2013).

Similar to how the Internet originally changed the way products and services were commercialized and marketed, the IoT provides new opportunities and new ways for companies to create value and organize their business models (Bucherer & Uckelmann, 2011), and it is considered the origin of the next technological and industrial revolution (Metallo, Agrifoglio, Schiavone, & Mueller, 2018). Furthermore, it seems that IoT is not being adopted at its full potential by companies, mostly because there is missing a rationale of how to use this new technological paradigm to add value to current businesses (Dijkman, Sprenkels, Peeters, & Janssen, 2015). Some researchers have been working on theories about the foundations for business models adapted to IoT based companies, but such research is still scarce and not enough to understand how these business models need to be different from other companies and how they should be built (Dijkman et al., 2015).

It is then still pertinent to look into the business models of companies that commercialize IoT based products and services, in order to understand how they can create value, and how those companies can deliver and capture the value created (Metallo et al., 2018). Furthermore, it is important to understand the business model evolution and possible drivers of change in the IoT companies, as there is an increasing tendency to study the business model, not as something static in a specific point in time, but as dynamic concept that innovates and adapts throughout the time (Saebi, Lien, & Foss, 2017).

The present study uses a qualitative research approach through a multiple-case study, in order to characterize the business models (BMs) of a group of companies that commercialize IoT-based products and services, in two different moments of their existence (in the beginning of their activities and at the time of data collection), to assess what leads to change those BMs. After comparing the past and present BMs, I expect to understand their evolution in each company, as well as what changed and the main factors that led to those changes, thus answering the following research question: "How and why do IoT-based companies change their business models?".

This dissertation is structured as follows: after this brief introduction, it starts with a literature review about the IoT technological paradigm, the different BMs concepts, and the BM change and evolution topic, further exploring the literature relating BM and IoT as well. Then, the methodology is explained, the result analysis is elaborated, and followed by the results discussion and final conclusions.

2. Literature review

In order to understand how companies that commercialize IoT based products organize, change and evolve their BMs, it is important to understand the challenges and opportunities that this technological paradigm brings, and explore the existing research regarding this topic. This section starts with a review of the key concepts: the IoT, business model concept and business model change and evolution, and further, the existing literature which relates business models and IoT is explored.

2.1 Key concepts

2.1.1 The Internet of Things (IoT)

Some researchers trace the origin of a concept that is similar to the Internet of Things back to the 19th century, when the inventor Nicola Tesla, theorized that in a future, the earth would be connected through wireless networks of devices, much more capable than the first telephone of that era (Atzori, Iera, & Morabito, 2017). After the development of the Internet, the earliest networks of connected devices started to appear in the beginning of the mid 1990s, such as tracking systems, alarms and fleet management solutions. Then, with the evolution of Internet speeds and hardware capabilities, it became easier and more relevant to integrate different things together into a common framework (Chase, 2013). In 1998, the term "Internet of Things" (IoT) was first used by Kevin Ashton of Procter & Gamble, when working with Radio-Frequency Identification (RFID) applied to supply chain solutions (Westerlund, Leminen, & Rajahonka, 2014).

These "Things" can be multiple mobile devices, or even general household objects, incorporated with sensors and communication technologies, such as RFID and wireless networks (Wi-Fi). The IoT is therefore, the interconnection (using the Internet) of objects from the physical world that are equipped with sensors, actuators and communication technology (Westerlund et al., 2014).

IoT technologies are viewed as software based platforms that allow a core functionality to be shared by complementary subsystems across a platform, providing an uplift of the functionality itself (Tiwana, Konsynski, & Bush, 2010). This approach to the IoT

technologies underlines the importance of the complementarity and synergy that exists with other different technologies (Metallo et al., 2018), and the dependence of the technical progress of those technologies, such as RFID, sensors, smart things, miniaturization, and nanotechnology (Westerlund et al., 2014). One example, is the evolution of the technology behind biosignal sensors, that enabled them to be small enough so they can be wearable, and the IoT technologies enables those sensors to be connected wirelessly, so doctors can monitor patient's biosignals remotely allowing their mobility inside or outside the hospital (Niyato, 2009).

The IoT technological applications are broad and still in the early stages of development, with only a very small part being currently available to the society (Atzori, Iera, & Morabito, 2010). Some of the main areas of application of the IoT are the Industry 4.0, logistics, mobility, healthcare, smart cities, home automation and data collection (Atzori et al., 2010; Chase, 2010).

Thus, the IoT is an important trend for the future of the Internet (Atzori et al., 2010) and it is considered to be the root of the next technological and industrial revolution, being able to modify companies' status and disrupt current markets, with deep organizational and managerial implications on both Business-to-Consumer and Business-to-Business levels (Metallo et al., 2018).

2.1.2 Business model concept

The term business model is being widely used since it was first introduced in the late 1950s (Osterwalder, Pigneur, & Tucci, 2005), although its definition is not well established, since then various definitions from various authors appeared in the literature, and the term was increasingly being used throughout the years (Wirtz, Pistoia, Ullrich, & Göttel, 2016; Foss & Saebi, 2017). There are multiple definitions that can be found in the literature, some of them are as follows:

- Porter (2001), determinate BM as a simple scheme that depicts how a company does its business and generates revenue.

- Morris, Schindehutte, & Allen (2005) define BM as a suscint picture of how a set of

interconnected strategic and economic components are arranged, in order to create long term competititeness in defined markets.

- Weill & Vitale (p. 34, 2001) outline BM as "a description of the roles and relationships among a firm's consumers, customers, allies, and suppliers that identifies the major flows of product, information, and money, and the major benefits to participants".

- Osterwalder et al. (2005) describe BM as a picture that represents the logic behind the value creation of a company, with an overall description of the activities aggregated by business components.

- Chesbrough & Rosenbloom (2002) portray BM as an important tool to connnect new techologies to the customer's needs, helping technological firms to explore those techologies and create new market outcomes and generate economic value.

The number of publications of scientific articles and books related to the BMs topic increased since 2004, as the interest regarding the research on this matter became more evident (Wirtz et al., 2016; Foss & Saebi, 2017). Furthermore, it seems that an increasing standardized business model is being developed in the literature, with more focus on the aggregated and simplistic depiction of the key company activities (Wirtz et al., 2016). This can be achieved by looking into the relevant components that make up the BM, as there are distinct approaches in the literature, and despite some BM approaches being more abstract than others, most of them can be aggregated into: strategic, customer & market and value creation components (Wirtz et al., 2016).

BMs growing interest may be also related with the rising of new technologies since the 1990s, as it is being widely used as a mechanism to understand the potential value incorporated in those new technologies and how they are transformed into market outcomes (Zott, Amit, & Massa, 2011). As previously mentioned, there are multiple frameworks for BMs found in the literature, but one frequently mentioned for its usability in understanding the important factors that enable companies to create and capture value, is the business model canvas (Osterwalder & Pigneur, 2010).

Osterwalder (2004) compared the most mentioned BM components in the literature and built his own framework, which was the basis for the business model canvas (Osterwalder &

Pigneur, 2010), and consists of nine basic building blocks: value proposition, customer segments, customer relationships, channels, key partners, key resources, key activities, cost structure, and revenues streams. Furthermore, Osterwalder (2004) aggregated those blocks into four important pillars, which are: product; customer interface; infrastructure management; and financial aspects. Figure 1 depicts the business model canvas nine building blocks (Osterwalder & Pigneur, 2010) in relation to the four important pillars of the BM (Osterwalder, 2004).

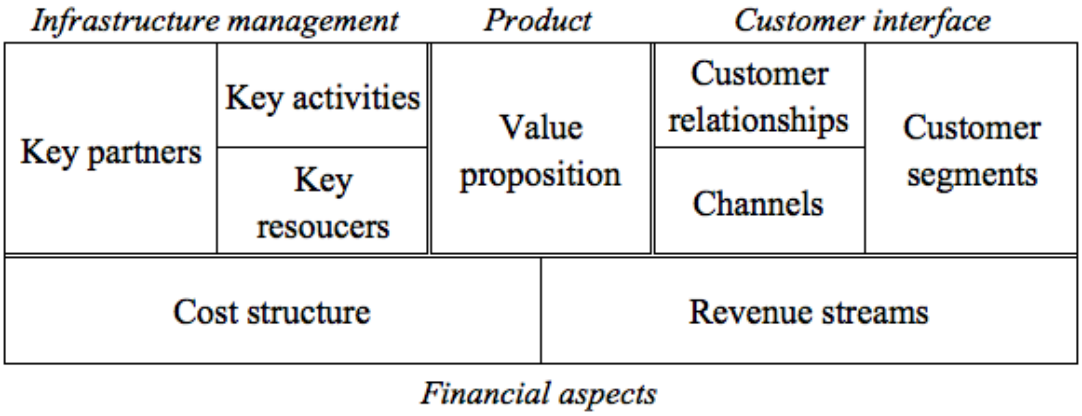

Figure 1 - Business model canvas ontology

Source: adapted from Osterwalder (2004) and Osterwalder & Pigneur (2010)

2.1.3 Business model change and evolution

Although there are various definitions found in the literature that points to a common understatement of a BM (Wirtz et al., 2016), there is still not much consensus regarding the different topics that are part of the BMs dynamics and innovation, and it is not clear whether some definitions point to the same occurrence (Foss & Saebi, 2018). This multitude of terms and definitions can also be observed concerning the topic change and evolution, as multiple authors use different terms to explain apparently similar phenomena of change and evolution:

- Aspara, Lamberg, Laukia, & Tikkanen (2013) uses the term "Business model transformation" to define the change on how a certain company creates value from one point of time to another;

- Teece (2010) refers to "Business model learning" to explain how a company adapts

its business model in order to face a competitor's new business model;

- Khanagha, Volberda, & Oshri (2014) describes "Business model innovation" as being a wider definition that includes incremental changes on the business models' components, extension and creation of parallel business models, and complexly disruption of the business model that can result in a completely different new one;

- Casadesus-Masanell & Zhu (2013) uses the term "Business model innovation" but defines it as the search of a new strategy to accomplish the creation and capture of value for the companies' stakeholders;

- Demil & Lecocq (2010) refers to "Business model evolution" as the process of calibration that results in changes in and between the business models core components.

Although the multiple definitions depicted above use different terms to explain apparently similar phenomena, they all mention one or two key factors identified by Wirtz et al., 2016: "change of the business model over time" and "factors to adapt the business model". Wirtz et al., (2016) used these two key factors to aggregate the literature under a common term, "change and evolution", this simplifies the different terms that are found in the literature and will be used to the purpose of this work.

As there are plenty of definitions that point to the change and evolution in BMs, there are also multiple reasons explored by different authors. Table 1 summarizes some of the literature that refers to change of BMs over time, and the reasons identified by the authors on the different papers analyzed.

Teece (2010) explores the fact that BMs evolve over time, mainly because entrepreneurs in the early stages of the company, have to take an "educated guess" of multiple factors, for example, what customers want and are willing to pay, and what are the structure costs associated with the ways to organize the business.

Chesbrough & Rosenbloom (2002), argued that sometimes, BMs need to adapt to the customer's reality, as this can often happen when the technology is not mature enough or does not fit correctly the customers' needs.

Author(s)	*Reason for change and evolution*
Chesbrough & Rosenbloom (2002)	Technology not mature / does not fit adequately customer's needs;
Siggelkow (2002); Morris et al. (2005)	Incorrect "fit" between internal and external components can influence change on the BM;
Morris et al. (2005); Teece (2006)	Companies start with incomplete BM and strategy, which evolves over time; Learning and experimentation on the different BM components results in change over time;
Demil & Lecocq (2010)	Business models are in a state of *permanent disequilibrium*; Inefficiency of the companies' resources lead to change;
Casadesus-Masanell & Zhu (2013)	Response to a competitor's innovation;
Khanagha et al. (2014); Saebi et al. (2017)	Change into the company's strategy can lead to incremental or radical changes into the BM;
Saebi et al. (2017)	An external opportunity or threat, can lead the BM to adapt.

Table 1 - Analysed literature concerning change and evolution in BMs.

As noticed by Teece (2006), learning and experimentation is recurrent in business and can lead to changes in the company. This argument is also made by Morris et al. (2005), who argue that learning and experimentation is part of the BM evolution, as companies start with an undeveloped BM and incomplete strategy that evolves over time as the company develops, learn and grow.

Furthermore, Morris et al. (2005) explore the idea of "fit" between internal and external components of the BM, for example, external factors can lead to the need to adapt internal components of a BM. Similarly, Demil & Lecocq (2010), exploit the idea that a company's

BM is in a state of *permanent disequilibrium,* as the BM components are always changing and influencing one another, and that resources are not always being used efficiently, which opens possibilities to new value propositions and better efficiency in exploring those resources.

Casadesus-Masanell & Zhu (2013) argue that companies can also change their BM to respond to a competitor's innovation. Khanagha et al. (2014), demonstrate that a change into the company's strategy is connected to a change in the BM, thus leading to either an incremental evolution of the BM, or even a radical change where a new business model replaces the older one. The same hypothesis is supported by Saebi et al. (2017), as the authors argue that external threats and opportunities can influence the strategy of the company, thus leading the BM to adapt adequately.

However, althoug there can be found plenty of references regarding change and evolution in BMs, manny of them are only focused in one particular phenomena or case study. Moreover, this is a field of research that is still not fully explored and lacks further research (Aspara et al., 2013; Wirtz et al., 2016). Wirtz et al. (2016) conducted a survey within the scientific community in the area of BMs, and concluded that "change and evolution" is the most signiticant area for furture research regarding BMs processes.

2.2 The IoT and business models

Despite the paradigm of IoT being studied since the 90s (Chase, 2013), only in recent years was there a significant increase of the number of Internet connected devices, alongside the number of companies applying and developing applications with those same devices. This time gap is believed to have occurred mainly due to the decrease of costs of applying this paradigm and to the elimination of technical barriers (Saarikko, Westergren, & Blomquist, 2017).

The technology behind the IoT, can be applied in a large variety of domains, such as manufacturing, healthcare and energy, to facilitate the development of new applications and the improvement of existing ones (Dijkman et al., 2015). One example of the application of IoT devices is the dynamic environment of products and services in which maintenance is

carried out. The capabilities created by IoT are important to be able to consider maintenance actions only when an actual need occurs rather than when it is presumed that it should be done, with respective risks of performing maintenance too early and not being able to optimize such service (Saarikko et al., 2017).

For the interest of commercially exploring IoT based products, new types of BMs must be created (Dijkman et al., 2015). However, there is scarce academic knowledge regarding IoT BMs and how they are different from others (Dijkman et al., 2015). Turber & Smiela (2014) argue that despite the existence of many BMs, there is no concrete one that supports the commercialization of IoT based products, and thus, further research regarding this topic is needed to fill this gap.

Some authors claim that the approach to BMs has changed over the last 10 years, as it seems that there was a shift from "what business models are" into the importance of understanding "what business models are for" (Westerlund et al., 2014). Furthermore, Westerlund et al. (2014) started by noting the importance of ecosystems for building new BMs, considering one of the factors that make companies fail to monetize IoT based products. The authors argue that managers can overcome the challenges that IoT creates, by designing their BMs considering an ecosystem approach, looking into the different key components of the business and how they interact as an ecosystem (Westerlund et al., 2014).

The ecosystem approach previously mentioned, may be too complex to underline and to benchmark different companies, as it lacks a plainer framework that provides an overall insight, such as the BM does. BMs are widely considered as relevant in the domains of innovation and technology management (Metallo et al., 2018) and an important mechanism to understand how the technology and the customer can be linked, helping companies to exploit the opportunities of new technologies and transform those into market outputs (Zott et al., 2011).

Dijkman et. al (2015), identified the most important BMs building blocks factors for IoT-based companies, using as baseline, the BM canvas from Osterwalder & Pigneur (2010). But dispite the importance of this work as the first BM framework for the IoT based companies, the authors acknowledge that their results are still broad, although they consider it as an important first step to fill the gap on this subject, and a starting point for future research (Dijkman et al., 2015).

Using the work from Dijkman et al. (2015) as a baseline, Metallo et al. (2018) focused on exploring which are the BM critical factors that play an important role into the value creation process for IoT based companies. However this provides a static deptiction of the BMs explored not looking on how they change and evolve. Although there are different types of IoT BMs suggested in the literature (Dijkman et al., 2015; Metallo et al., 2018), to the best of our knowledge, none is focused on the way they change and evolve.

Thus, it is pertinent to study IoT based companies BMs, as there is still limited scientific work about this topic and further research is needed. In addition, as previously mentioned, being change and evolution identified as one of the most important future research subjects inside the BMs topic (Wirtz et al., 2015), and the increasing tendency to study the BMs as a dymanic and evolutive concept (Saebi et al., 2017), it is relevant to further explore the change and evolution that occurs in BMs from IoT-based companies.

3. Methodology

The choice of the methodology to be used should depend on the basis of the research problem to be explored (Khairul, 2008). This work aims predominantly to explore how companies that commercialize products and/or services based on the IoT, organize their BMs and how those BMs change and evolve. Therefore, contributing to existing work focused on understanding BM change and evolution, thus falling into one of the features of the qualitative research, identified by Yin (2015).

Furthermore, qualitative research is suitable for the analysis of complex processes and concepts that cannot be quantified (Khairul, 2008), which again relates to the focus of this work, since we cannot measure how companies do and change their BMs, instead, it is appropriate to have an insight and an understand on how they do it (a complex evolutionary process).

One common method used in qualitative research is the case study, which despite being often criticised by its lack of exactitude or reliability, is useful for analysing the properties of organizations and their activities (Khairul, 2008) and to explore the strategy implementation of organizations (Voss, Tsikriktsis, & Frohlich, 2002), thus being the appropriate method to use in this work.

Moreover, a multiple-case study was carried out, in order to sustain the findings. As argued by Khariul (2008), surveying a number of organizations helps to increase the precision, rationality and reliability of the research. Additionally, multiple-case studies could reduce the scope of study, yet, it can increase the external validity, and help to prevent the observer bias (Voss et al., 2002).

3.1 Data collection

For collecting data, a semi-structured interview was used, as it offers malleability in order to accommodate the differences in the surveyed companies (Khairul, 2008). As the purpose of this work is to compare the companies' initial and current BMs, the questions were elaborated in order to accommodate the template of the BM canvas (Osterwalder & Pigneur, 2010), since having a predetermined framework of core elements, can help to identify

changes more consistently across companies (Siggelkow, 2002). The questions elaborated for the semi-structured interviews were also prepared to enable collecting data to fill that canvas for the two moments, initial BM and current BM, where current BM refers to the BM at the moment of the interview.

A total of four companies were interviewed between March and May of 2018. The targeted companies offer products and/or services based on IoT technologies, and were micro, small and medium sized technological enterprises, located in Portugal. They are characterized in Table 2.

Three of the interviews took place on the company's premises, one was made using video call, and all of them were conducted with a top manager of the company. The interviews were recorded to assist with the analyses. The average interview time was of 45 minutes, being the longest 58 minutes and the shortest 38 minutes long.

Company	***Sector***	***Meeting type***	***Interviewee(s)***	***Size***[1]	***Year founded***
A	Connected transportation	In person	Product manager	Medium	2012
B	Medical devices	In person	Co-founders	Small	2015
C	Biotechnology	Web call	CEO	Small	2007
D	Data/analytics	In person	Co-founders	Micro	2009[2]

Table 2 - Summary of the interviewed companies.

The questionnaire used to assist the interview, was elaborated in order to have the different core building blocks of the business model canvas (Osterwalder & Pigneur, 2010), described by the interviewees in the same order. The questionnaire is depicted in the Appendix A.

[1] Considering the staff headcount as: Micro <10, Small <50, and Medium <250 employees.
[2] Company D was actually founded in 2018, but it is a spin-off on a company that filed bankruptcy one year earlier. The founders were employees from the old company and they applied the same core business model with some changes. For the propose of this work, both companies will be considered as one, and the foundation year the one from the original company - 2009.

The interviews were initiated with a general question about the company's products/services, age and number of employees (a summary can be found in Table 2).

The initial BM was then described, using a blank BM canvas template as previously mentioned, in order to accommodate the answers, and following the logic as depicted in the questionnaire (Appendix A).

Then, the same procedure was applied, but in order to draw the current BM (at the time of the interview), using again the BM canvas template.

To conclude the interview, the open question "what changed and why it changed?" was asked. An overview of the answers to this question can be found in the Appendix B.

3.2 Data analysis

Although the focus of this work is to explore the change and evolution of the BMs, that would not be possible without first understanding how those companies organize their BMs, thus that was the first part of the results analysis: describing the initial BM and comparing the building blocks factors to the ones suggested on the framework from Dijkman et al. (2015), in order to have a baseline for further analysis. Afterwards, each company's current BM was explored, highlighting the differences between both initial and current BMs, as well as describing the visible changes between those same models.

Then a cross-comparison of the companies' BMs was made, using the Dijkman et al. (2015) suggested building block factors, in order to have a common framework that allowed a comparison between the four companies initial and current BMs. Finally, a summary of the interviewees' responses to the open question "what changed and why it changed?" was made and used to further explore the main drivers that led to the changes observed in the comparison between the initial and current BMs.

In the next section, the results from the different parts of the analysis described previously are presented, following a presentation structure with the same sequence as the rational described for the analysis. That section ends with a discussion of the results, based on the literature explored in the beginning of this work and on the main results.

4. Results and discussion

4.1 Company A

Company A is a technological SME that initially commercialized IoT-based technological solutions to provide Internet connections in the transportation systems of the cities, which enabled Internet connected mobile networks cheaper than the cellular ones.

4.1.1 Initial business model

Company A's initial BM is depicted bellow (Figure 2), representing with an asterisk (*) the block factors that match the IoT business model framework suggested by Dijkman et al. (2015).

<table>
<tr>
<td rowspan="2">Key Partners
– Internet providers*
– City government
– Local infrastructure partners*</td>
<td>Key Activities
– Product development*
– Software development*
– Hardware implementation*</td>
<td rowspan="2">Value Proposition
– Solution that enables vehicles to be connected to the Internet, providing them to act as Wi-Fi Hotspots.
– Cheaper than Cellular Internet network
– Network manageable via the Cloud*</td>
<td>Customer Relationships
– Case studies and Pilot testing
– Roll out of the solution
– Follow up and support*</td>
<td rowspan="2">Customer Segments
– Public transport companies
– Industrial Spaces
– Sate-owned enterprises
– (Niche markets) *</td>
</tr>
<tr>
<td>Key Resources
– People*
– Cloud services
– Network Maintenance</td>
<td>Channels
– Direct Sales*
– Trade events
– Digital*</td>
</tr>
<tr>
<td colspan="3">Cost Structure
– Hardware*
– Network Maintenance costs*
– Engineering costs*
– Could services*</td>
<td colspan="2">Revenue Streams
– Monthly Fee, per Vehicle*</td>
</tr>
</table>

Figure 2 - Company A's initial BM.

Starting with the value proposition of the initial BM, it can be summed up to cost reduction, convenience/usability and newness, which are three of the building block factors suggested

by Dijkman et al. (2015). The customer segments started to be niche markets, and the customer relationship was personal/dedicated assistance made through direct and digital sales channels.

Looking into the three initial key partners, they were the Internet providers and local infrastructure partners (both can be considered as service partners, suppliers of company A), and the city government. Key activities and key resources also seem to match the model of Dijkman et al. (2015) with the exception of the hardware implementation, as a key activity which is not referred in that model, but it was important for this company, as its uniqueness relied on the hardware.

Lastly, looking to the financial aspects, the cost structure was mainly costs with hardware, engineering and IT costs concerning the Cloud and network maintenance. On the revenue side, the initial income was made through a monthly subscription fee. Both the financial aspects again show strong alignment with some of the factors suggested by Dijkman et al. (2015).

4.1.2 Current business model

Company A's BM changed significantly since the beginning of their operations, as depicted bellow in the Figure 3, where the key changes are underlined. Representing with an asterisk (*) the block factors that match the IoT business model framework suggested by Dijkman et al. (2015).

Company A's BM most visible changes were on the product and the customer interface sides, in order to accommodate a new market, much larger than the market they initially targeted. The value proposition also adapted to the new market, although it is still focused on the cost reduction and convenience/usability, plus offering to be a baseline for multiple services providing the target customers a solution customisable to their needs.

Although the most visible changes were observed on the product and customer interface, moving to a new market made the company also adapt the remaining BM with much less changes, but those required to match the product and the customer interface. The infrastructure management adapted slightly, with the inclusion of business development as a

key activity, hardware integration and patents as key recourses, and automotive industry analysts and experts as key partners.

This difference of scale of change between the several pillars of the BM can be justified with the technology that was originally developed in the early stages of the company remained the same and it was only its use that adapted to the new target market. But the value proposition factors remained mostly the same: cost reduction, convenience/usability and newness, with the inclusion of the customization factor as previously mentioned.

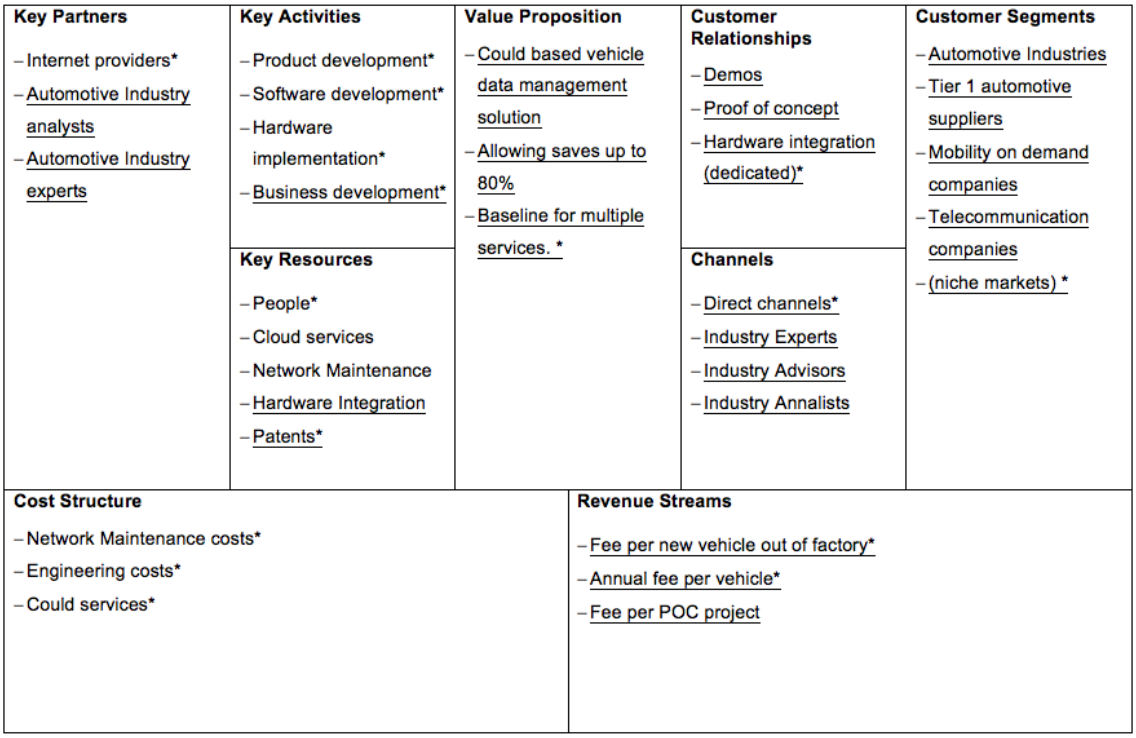

Figure 3 - Company A's current BM.

Customer relationships are still made on a dedicated/personal assistance, but adapted to the targeted market, plus adding the hardware integration factor as important for the new market, as the company needs to integrate their solution with the existing different customer's hardware. Moreover, the channels suffered an increase of the sales force recurring to the industry experts and analysts some of which doubling as key partners also.

The financial aspects remained the same on the cost structure side, with the elimination of hardware costs. It adapted on the revenue streams side, with the introduction of a fee per proof of concept project, as well the fee per vehicle with their technology.

4.2 Company B

Company B is a technological SME, operating in the medical devices sector, which offers a technology to assist the process of prosthetic fitting, using IoT technology to enhance their value proposition, reduce costs and secure their intellectual property.

4.2.1 Initial business model

Company B's BM is depicted on Figure 4, highlighted with an asterisk (*) the factors that match the framework purposed by Dijkman et al. (2015).

Looking into the company B's value proposition, it started to be focused on "getting the job done", by providing the targeted customers a solution to accomplish the correct fit of the prostheses, together with a significant cost reduction that it could bring to them. Both of those benefits fall into the building block factors purposed by Dijkman et al. (2015). On the customer interface side, the customer segments were summed up to a niche market that encompasses rehabilitation, and prosthetic and physiotherapy centres.

<table>
<tr>
<td rowspan="2">Key Partners
– Paralympics
– Rehabilitation centers
– Physicians</td>
<td>Key Activities
– R&D*</td>
<td rowspan="2">Value Proposition
– Help the correct fit of a prostheses
– Save time in the process (cost reduction) *</td>
<td>Customer Relationships
– Dedicated service*</td>
<td rowspan="2">Customer Segments
– Rehabilitation Centers
– Physical therapy centers
– Prosthesis centers
– (Niche markets) *</td>
</tr>
<tr>
<td>Key Resources
– Employees*
– Competences and expertise*</td>
<td>Channels
– Direct Sales*</td>
</tr>
<tr>
<td colspan="3">Cost Structure
– Human resources costs*
– R&D*</td>
<td colspan="2">Revenue Streams
– Annual Fee*
– Project Fee*</td>
</tr>
</table>

Figure 4 - Company B's initial BM.

The customer relationships were made through a dedicated service and using a direct sales channel. Key activities and key resources were focused on the R&D and the employee capabilities respectively, key partners on the other hand, were very specific for the area of prosthetics, and, therefore, not alignment with the framework of Dijkman et al. (2015).

The financial aspects contemplated human resources and R&D as cost, and the annual fee/ project fee as a revenue stream, which matches the framework of Dijkman et al. (2015).

4.2.2 Current business model

Company B's BM changed since the beginning of their operations, as depicted bellow in Figure 5. The key changes are underlined and the factors that match the framework purposed by Dijkman et al. (2015) are highlighted with an asterisk (*).

<table>
<tr>
<td rowspan="2">Key Partners
– Paralympics
– Handicap Organizations</td>
<td>Key Activities
– Assembly
– System monitoring
– R&D*</td>
<td rowspan="2">Value Proposition
Close to perfect fit between the prosthesis and the residual limb which reduces number of times the fit has to be reassessed thus saving costs. *
Tablet app provides convenience for the user, using cloud computing and keeping records of patients on demand*</td>
<td>Customer Relationships
– Dedicated service*</td>
<td rowspan="2">Customer Segments
– Rehabilitation Centers
– Physical therapy centers
– Prosthesis centers (Niche markets) *</td>
</tr>
<tr>
<td>Key Resources
– Cloud services
– Data
– Hardware sensors
– Employees*
– Competences and expertise*</td>
<td>Channels
– Direct Sales*
– Events
– Medical Publications</td>
</tr>
<tr>
<td colspan="3">Cost Structure
– Human Resources*
– R&D*
– Data management*</td>
<td colspan="2">Revenue Streams
– Annual Fee*
– Project Fee*
– Consumables/ Disposable material sales</td>
</tr>
</table>

Figure 5 - Company B's current BM.

It appears that the changes that occurred into the company B's BM are more incremental than radical. Starting with the value proposition, in the beginning it was more focused on the

technology itself and the faster results that that technology provided to the targeted customers, without understating the true need for some markets, while at the current BM, the focus is clearly on the benefits for the customer, namely for the job to be done of the customer.

The current value proposition is still focused on the need to save costs, but not by providing a faster solution, but a better solution that allows the patients to the return less times to the centers. Furthermore, the creation of a tablet app integrated with cloud computing, allows the solution to be more attractable, since it provides convenience and better usability, creating the possibility to easily keep track of the patient's history on demand, and since the computing is made in the cloud, all the customer needs is a tablet, eliminating the need for extra computing hardware, which would increase the price of the solution. In order to accommodate the new value proposition, new key resources and key activities were added, such as cloud services and system monitoring, respectively. Also on the key resources, the hardware sensors and data became more relevant, and assembly became also one of the current key activities. Regarding the key partners, the Paralympics remained one important partnership to promote the product and Handicap Organizations were added for the same reason.

On the financial aspects, data management became part of the cost structure as it is necessary to support the new value proposition and related key activities and key resources. On the revenue streams, consumables/disposables were added, as the company understood that some hardware used in the fitting process was better accepted by the customer if it was not durable and reusable, but disposable, which became an opportunity to add extra revenue.

4.3 Company C

Company C is a technological SME company, that operates on the biotechnology sector, and commercializes sets of wearable biosignals monitoring products for research or physiotherapy, based on a platform using IoT technology.

4.3.1 Initial business model

Company C's BM is depicted on Figure 6, highlighting with an asterisk (*) the factors that match the framework purposed by Dijkman et al. (2015).

Company C BM started with a value proposition that can be summed up to some of the building block factors identified by Dijkman et al. (2015): comfort, convenience/usability and "getting the job done". Customer segments started with a niche market, very focused on R&D institutions and Universities, recurring to direct and reactive sales, using the scientific community as an important relation, and providing a dedicated service through web sales and scientific conferences channels.

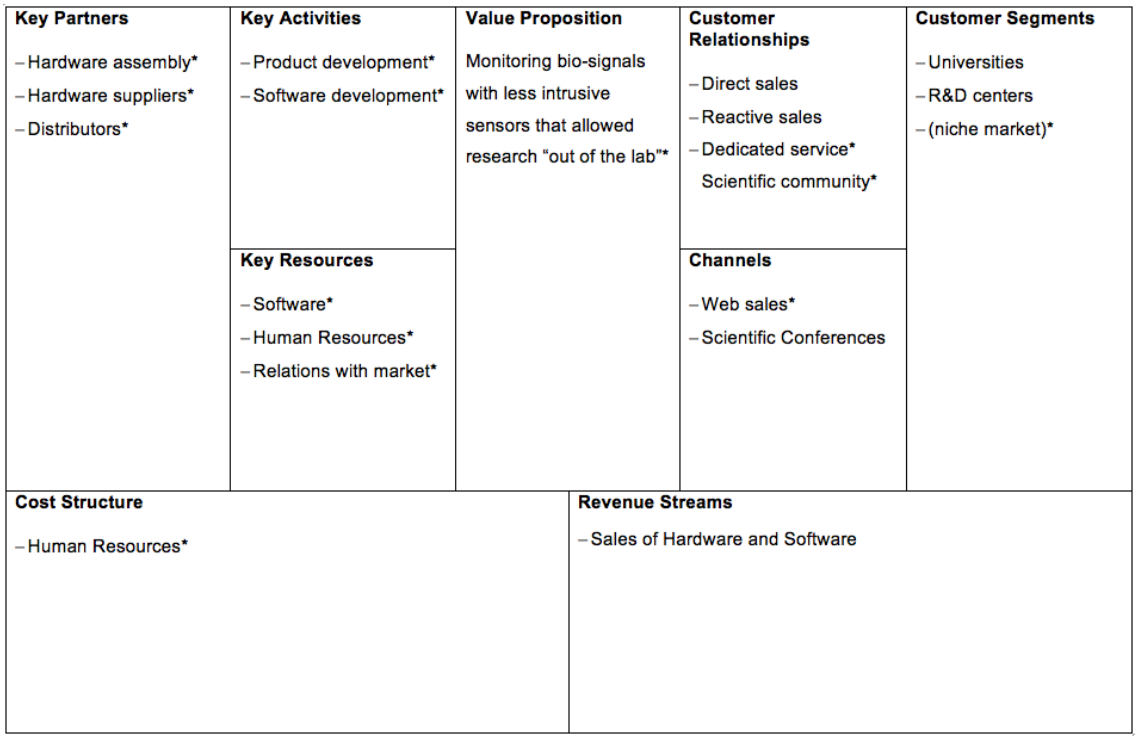

Figure 6 - Company C's initial BM.

The infrastructure management is a complete match with the model purposed by Dijkman et al. (2015): the key activities were product and software development; key resources are software, personnel and relations; and key partners were the hardware producers, suppliers and distributors.

Regarding the financial aspects, the main cost was only with personnel and the revenue

streams is the sale of both the hardware and software products, only this last one not being a factor identified in the framework from Dijkman et al. (2015).

4.3.2 Current business model

Company C's BM adjusted alongside their years of operation, as depicted bellow in the Figure 7, where the key changes are underlined. The factors that match the framework purposed by Dijkman et al. (2015) are highlighted with an asterisk (*).

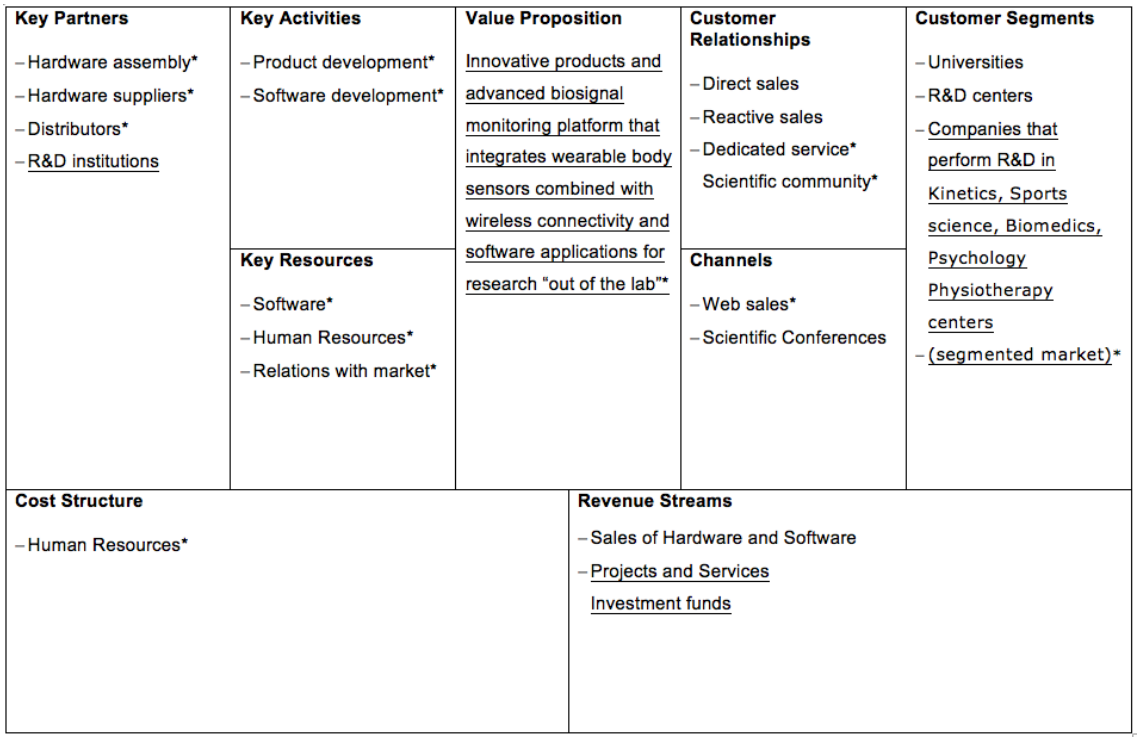

Figure 7 - Company C's current BM.

Company C's BM change was incremental along the years, not having any radical visible redesign. Staring with the value proposition, it evolved from one product, to multiple products, integrated with a platform that enhances their usability, allowing customisation and better convenience for customers. Customer relationships and channels remains the same, although the customer segments changed from a niche market focused on R&D and Universities, for a more segmented market that also includes physiotherapy centers and private companies, from multiple and diverse industries, that are showing interest in perform R&D in areas such as kinetics, sports sciences, biomedics and psychology.

On the infrastructure management side, it remains mostly the same, only with the inclusion of some R&D institutions as partners and not only customers as in the initial business model.

The financial aspects show that the principal cost is still with personnel, and concerning the revenue streams, besides the sales of hardware and software, now are also included Projects and Services as an additional revenue stream for the company, as well as Investment funding.

4.4 Company D

Company D is a technological SME company, that develops solutions for tracking people and objects, recurring to technology based on the IoT paradigm.

4.4.1 Initial business model

Company D's initial BM is depicted in Figure 8, highlighting with an asterisk (*) the factors that match the framework purposed by Dijkman et al. (2015).

<table>
<tr>
<td rowspan="2">Key Partners
– Launching customers*</td>
<td>Key Activities
– Software Development*</td>
<td rowspan="2">Value Proposition
Positioning and tracking of people using GSM triangulation*</td>
<td>Customer Relationships
– Co-Creation*</td>
<td rowspan="2">Customer Segments
– Shopping Centers
– Large Retailers
– (niche market) *</td>
</tr>
<tr>
<td>Key Resources
– Cloud services*
– Software*</td>
<td>Channels
– Direct Sales*</td>
</tr>
<tr>
<td colspan="2">Cost Structure
– Human Resources*
– Sales and Marketing*</td>
<td colspan="3">Revenue Streams
– Set Up Fee*
– Monthly Fee*</td>
</tr>
</table>

Figure 8 - Company D's initial BM.

Company D's initial value proposition can be divided into both newness and "getting the job done", matching the framework purposed by Dijkman et al. (2015). Customers segments were initially focused on a niche market of shopping centers and large retailers, being co-creation the main customer relationship made through a direct sales channel.

The key activities were software development, and the key resources were software and could services, this shows again close alignment with the building block factors suggested by Dijkman et al. (2015). Such close alignment also happens on key partners, as they were initially the launching customers.

The financial aspects show that the cost structure was mainly with personnel, IT expenses in could services, and marketing & sales cost. On the other side, a setup fee and a monthly subscription fee were the revenue streams. Both also match the framework purposed by Dijkman et al. (2015).

4.4.2 Current business model

Company D's current BM is depicted on the Figure 9, where the key changes are underlined. The factors that match the framework purposed by Dijkman et al. (2015) are highlighted with an asterisk (*).

Company D suffered a deep reformulation, although the current value proposition is very similar, the technology supporting it is completely different, but still keeping the same newness and "getting the job done" as the original one.

This change in the technology also opened new opportunities for different markets, since it is now capable of tracking not only people but also objects. A wider variety of applications for different markets became possible, leading the company to segment the market, adapting the business model accordingly. Moreover, on the customer interface side, there is the inclusion of automated services, such as dashboards from where the customer can access the data, and the consultancy service option.

<table>
<tr>
<td>Key Partners
– Service providers*</td>
<td>Key Activities
– Software Development*
– Hardware assembly

Key Resources
– Cloud services*
– Software*</td>
<td>Value Proposition
Identify, position and tracking of people and/or objects in a determinate space*</td>
<td>Customer Relationships
– Co Creation*
– Automated services*
– Consultancy

Channels
– Direct sales*</td>
<td>Customer Segments
– Retailers
– Traffic authorities
– Security companies
– Resorts
– Events companies
– (segmented market) *</td>
</tr>
<tr>
<td colspan="3">Cost Structure
– Human Resources*
– Hardware*
– Cloud based services *</td>
<td colspan="2">Revenue Streams
– Set Up Fee*
– Monthly Fee*
– One-time consultancy project fee</td>
</tr>
</table>

Figure 9 - Company D's current BM.

On the infrastructure management side, it is clear that it remained mostly the same, with the inclusion of some hardware assembly, as it needed to support the new technology behind the value proposition.

The financial aspects also remain the same, with the exception of the consultancy project fee, which was added to the already existing setup fee and monthly fee.

4.5 Business models comparison

An overall alignment with the building blocks factors proposed by Dijkman et al. (2015) is visible on the BM's previously analysed. Thus, a cross-comparison between the four companies can be made, using those same building factors mentioned previously. Through this comparison, it should be possible to understand which building block factors are the most present, and if the changes in the business model accommodated more, less or the same number of these factors.

Factors	Company A		Company B		Company C		Company D	
	Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM
Newness	x	x					x	x
Perfomance								
Customization		x			x	x		
"getting the job done"			x	x	x	x	x	x
Design								
Brand/Status								
Price								
Cost reduction	x	x	x	x				
Risk reduction								
Accessibility								
Convenience/usability	x	x		x	x	x		
Comfort					x	x		
Possibility for updates								

Table 3 - Value proposition comparison by building block factors.

Table 3, shows that the building block factors from the value proposition changed in the companies A and B, and remain the same in companies C and D (i.e., although they might have changed, those changes were incremental and remained focused on the same building block factors). The most used building block factor is "getting the job done" to answer adequately the customers' needs, followed by convenience/usability.

	Factors	Company A		Company B		Company C		Company D	
		Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM
Customer segments	Mass market								
	Niche Market	x	x	x	x	x		x	
	Segmented						x		x
	Multi sided platform								
Channels	Sales force	x	x	x	x			x	x
	Web sales	x				x	x		
	Own stores								
	Partner stores								
	Wholesaler								
Customer relationships	Personal assistance								
	Dedicated assistance	x	x	x	x	x	x		
	Self-service								
	Automated service								x
	Communities					x	x		
	Co-creation							x	x

Table 4 - Customer interface comparison by building block factors.

The customer interface comparison is portrayed above on Table 4. It is evidenced that only company B remained the same. Company C has the same number of block factors on both the initial and current BMs, but it changed their customer segments, which happened on companies A and D as well. Dedicated assistance seems to be the most relevant building block factor regarding customer relationships, and sales force the most important channel,

with web sales being the clear alternative. Furthermore, both companies C and D changed their customers to a segmented market, and companies A and B remained focused on niche markets (although company A changed completely their customer segments, they are still a niche market).

	Factors	Company A		Company B		Company C		Company D	
		Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM
Key Resources	Physical resources								
	Intellectual property		x	x	x				
	Employee capabilities	x	x	x	x	x	x		
	Financial recources								
	Software							x	x
	Relations					x	x		
Key Partners	Hardware producers					x	x		
	Software developers								
	Other suppliers								
	Data interpretation								
	Launching customers							x	
	Distributors					x	x		
	Logistics								
	Service partners	x	x						x
Key Activities	Customer development		x						
	Product development	x	x	x	x	x	x		
	Implementation; Service	x	x						
	Marketing; Sales								
	Platform development								
	Software development	x	x		x	x	x	x	x
	Partner management								
	Logistics								

Table 5 - Infrastructure management comparison by building block factors.

Depicted on Table 5 are the infrastructure management block factors. Only company C did not change here. Companies A, B and D changed their block factors, but only D maintained the same number. On the key resources side, only company A added one more factor, with no change on the other companies. Regarding the key partners, there are no changes, with the exception of company D, due to an incremental improvement of the solution provided that required offering additional services. For key activities, both company A and B added one more factor to the current BM, and companies C and D remained the same.

The most relevant key resource is the employee capabilities, and the most important key activities are both product and software development, which makes sense for companies such as these that rely heavily on high-technology. On the key partners side, there is no relevant building block factor, as all the companies show substantial differences.

Table 6 outlines the financial aspects comparison. Only company C does not show any change in this case, being the changes in all the other three companies substantial, in

particular on the cost structure, which seems to make sense since as the company grows its cost structures adapts to a more hierarchical company.

	Factors	Company A		Company B		Company C		Company D	
		Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM
Revenue streams	Asset sale								
	Usage fee								
	Subscription fees	x	x	x	x			x	x
	Lending/renting/leasing								
	Licensing								
	Brokerage fees								
	Advertising								
	Startup fees								
	Installation fees		x		x			x	x
Cost structure	Product development cost			x	x				
	IT cost	x	x		x				x
	Personnel cost	x	x	x	x	x	x	x	x
	Hardware/production cost	x							x
	Logistics cost								
	Marketing & sales cost							x	

Table 6 - Financial aspects comparison by building block factors.

Company D kept the same revenue streams, and both company A and B added the installation fees to the current BM. Regarding the cost structure, the IT cost remained on both initial and current BM for the company A, but it was added on both companies C and D current BMs.

The most important building block factor on the revenue side is the subscription fees, and on the cost side is the personnel cost, which is mentioned in all BMs.

4.6 Change and evolution

Table 7 illustrates a summary of the main changes identified by the companies when asked the open question "what changed and why it changed?" and the reasons provided for such changes.

Company	*What changed?*	*Why it changed?*
A	Target market changed. Transition from software and hardware solution, to software only.	Original target market was not enough to grow within the strategic objectives. Rising interest from the automotive on IoT solutions as an opportunity for the company to adapt the pitch of their base technology to this market.
B	Value proposition changed and evolved to the customer's needs. Revenue structure changed accordingly (e.g. introduction of disposable sales materials)	In the beginning the company was too focused on the product and it was not adapted to the market needs, it evolved along the time according to the customer's feedback.
C	New products emerged along the time Introduction of R&D services.	Company's involvement with the market pushed the development of new products to respond to their needs
D	Technology supporting the value proposition. Cost structure.	The technology behind the original value proposition failed to effectively accomplish it. Cost structure was not adequate to the business model.

Table 7 - Summary of what changed and why it changed.

Starting with company A, it is clear that a strategic decision supported by an opportunity in a different, more appealing market, was the main driver of change. The original target market was not scalable enough to meet the company's growth objectives, furthermore, since most of the clients of that market were public companies, the company was subject to long waiting times on public tendering processes, which was not feasible to meet the company's objectives. The possibility to use their technology and adapt the pitch of their value proposition to a bigger and more scalable market was appealing enough for the company to adapt their BM structure in that direction, and as underlined in the Figure 3, new building block factors were added to the BM in order to accommodate that strategic change.

Company B in the beginning was too focused on the technology they developed, and not on the correct value proposition that the product could offer to the potential customer. This

meant that although the technology was capable of solving a problem, that problem was not correctly identified in the original value proposition. After some learning process and feedback from the first customers, the company adapted the value proposition and the revenue structure, in order to converge with the market needs. The changes underlined in Figure 5, depict that the current BM evolved as a whole in that direction, i.e., a new value proposition required new key activities and resources to be added, as well as new costs to support them.

Company C started with a solid value proposition and a good fit of the different components. The building block factors that changed are underlined in the Figure 7, and they seem to depict an incremental change in the BM, as the main ones were the emergence of new products and services and the adaptation of the value proposition to the new portfolio. Due to a good relation with the target market, and after the good reception of the original product, company C was able to understand other market needs and develop new solutions in response to the customer's demand. Also resulting of the company's relation with the customers and key partners, the target customers were segmented, as other markets showed interest into the company C's portfolio of biosignals monitoring solutions.

Company D's main change resulted from a failed value proposition resulting from a technology that did not succeed to accomplish such value, and an inadequate cost structure, that was no longer able to support the company when the costumers realized the value proposition was not fulfilled. A new technological solution was developed to resolve the original problem of the value proposition, thus generating changes to the original BM, as visible in Figure 9 (the market became segmented and a new revenue stream was added to the BM).

Considering the BMs (initial and current) as described by the companies (depicted on Figures 2 to 9) it is possible to elaborate a table that summarizes the intensity of the changes observed in those BMs. Using a scale from 0 to 3, it is possible to assess the number of building block factors that changed, or evaluate the observed changes (in the case of the value proposition, which is not quantifiable), between the initial and current BMs components.

Table 8 portray the significance of the changes observed, between the four companies' initial and current BM's, being the scale criteria as follows: 0 – no change; 1 – incremental change (1 or 2 factors changed); 2 – moderate change (more than 2 factors changed); 3 – radical change (all of the factors changed).

	Product	*Customer Interface*			*Infrastructure management*			*Financial Aspects*	
Company	Value proposition	Customer segments	Channels	Customer relationships	Key Resources	Key Partners	Key Activities	Revenue streams	Cost structures
A	2	3	2	2	1	2	1	3	1
B	2	0	2	0	2	1	1	1	1
C	2	2	0	0	0	1	0	1	0
D	2	2	0	1	0	1	1	1	2

Table 8 – Significance of the BMs changes.

Table 8 evidences that the company with the most substantial changes observed between the initial and current BMs, was company A, which was also the only company where radical changes were observed. On the other hand, the company that appears to have less change its BM, was company C.

Considering the building blocks where the most important changes occurred, it is evidenced that the main changes were primarily on the value proposition, followed by the customer segments. The building blocks where the observed change was less relevant were: key resources, key activities and customer relationships.

4.7 Discussion of results

Starting with the BMs building block factors, it is evidenced that the framework proposed by Dijkman et al. (2015) for IoT companies does show multiple similarities with the BMs described in this work. There is no BM analyzed that matches 100% of these factors, although considering this as a general framework, it is expected to differ between different industry sectors, as pointed out by the authors (Dijkman et al. 2015). This is visible in some building blocks factors, for example in the key partners, were only a few of the factors

suggested in that framework matches the ones from the BMs analysed, and where the type of key partners of each company differ from the others.

As evidenced in Tables 3 to 6 (a summary of the four tables can be found on the Appendix C), with the exception of company C, all the other companies seem to have more alignment of the building blocks factors with those identified by Dijkman et al. (2015), on the current BM than they had in the initial one. It is also interesting to observe that company C, whose initial BM was very close to the framework from Dijkman et al. (2015), is the company that shows less change in the current BM. All of these observations provide support to that framework, which is one important finding for IoT-based companies.

As evidenced in Table 7, the main drivers that lead the analyzed companies to change their BMs, were different in all cases. This heterogenic result does mirror the same variety of results found in the literature which regards the change and evolution of BMs (Table 1).

Starting with the company A, the analysis confirms the hypothesis identified by Saebi et al. (2017), as it is evidenced that an external opportunity influenced a changed into the company's strategy. Furthermore, as Khanagha et al. (2014) argue, a change to the company's strategy is connected to a change in the BM, thus leading to either an incremental or a radical change, as observed in company A, which was also the company were the most radical changes were visible in the BM.

Company B's case resembles the problem identified by Chesbrough & Rosenbloom (2002), as the solution originally provided did not fit adequately the customer's needs, so they needed to adapt their BM accordingly. Moreover, this case also evidences that learning and experimentation was an important driver of change and adaptation of the different BM components, which is a scenario explored in the works of Morris et al. (2005) and Teece (2006).

Although company C was the company that changed less, it seems that the incremental changes observed, were influenced by external components of the BM. Both key partners and customer segments, were the drivers of change in this case, as noticed by Saebi et al. (2017), an external oportunity can unfluence the BM do adapt. Moreover, it seems as learning and experimentation (Morris et al., 2005; Teece, 2006), was also the cause of the evolution

of company C's BM, as they evolved their product line by learning the needs of their customers.

In the case of company D, the main driver of change was the technology that failed to articulate with the BM value proposition, which is a phenomena identified by Chesbrough & Rosenbloom (2002) as essential to a successful BM. Furthermore, there was inappropriate fit between some of the BM internal factors, the cost structure was not adequate to the revenue stream, and that inappropriate fit is a reason that leads to change as identified by Siggelkow (2002) and Morris et al. (2005).

Nevertheless, it is not evident whether the reasons for these changes are specific for IoT based companies, as those are general reasons that could have been observed in other companies from different industries and sectors.

Furthermore, it is evidenced that the value proposition was the building block that suffered the most significant changes across companies, a result which can be supported in the literature, as the value proposition is identified by some authors as the most important building block for IoT based companies (Kiel, Arnold, Collisi, & Voigt, 2016; Metallo et al., 2018) and critical for the success of the BM (Hwang & Christensen, 2008).

In general, all the companies' value proposition changed, either adding new products/features to it, or completely changing it, as it was the case of company A. As pointed out by Hwang & Christensen (2008), the value proposition is the starting point of the BM desing, and the other BM building blocks should be developed arround it. Once the BM model is established, only value propositions that fit correctly the remaining blocks can be sucessfully implemented in the market (Hwang & Christensen, 2008). Some of the previously analyzed value propositions seem to have influenced a change in the other BMs building blocks. As already mentioned, company A changed its value proposition to respond to a new market opportunity that required the company to completely change the customer interface and the revenue streams. Company B also changed their value proposition, and in order to achieve it, they needed to implement new key activities and key resources, which led to changes on the financial aspects as well. Company D new value proposition also resulted in further changes on the BM, as the new technology adopted implicated new key activities and cost structure. The exception to this, seemed to be the company C, as the value proposition did not seem to influence the other BMs building blocks, but the other way

around, as customers' demands led the company to develop new products, develop a platform, and offer new services.

On the infrastructure management side, all the companies adopted software development on the initial BMs, with the exception of company B that adopted it later. This evidences the importance of this building block factor in all companies, as software development is needed to establish an IoT infrastructure (Atzori et al., 2010).

One particular cost factor that is mentioned in three of the current BMs analyzed, is the cloud computing. Company A mentioned it on the initial BM, and both company B and D adapted it after. This change to cloud computing can be justified because it is easy scalable, without the need to invest in computing hardware, which is relevant particularly for SMEs (Marston, Li, Bandyopadhyay, & Ghalsasi, 2011).

Additionally, there are other specific findings, in regards the building block factors that were adopted on the current BM in two or more companies. Namely, the inclusion of the installation fee as a revenue steam in both companies A and B (company D adopted it from the beginning), and the change that companies C and D made on the customer side, as they adapted to a segmented market. Nevertheless, to the best of our knowledge, there is lack evidence in the literature to support these changes as being specific and relevant for IoT companies. The installation fee as revenue stream seems to make more sense for IoT companies, if the solution that is sold to the customers is closer to a turnkey solution (which is the case of companies A, B and D). Concerning the evolution towards a segmented market, it seems not specific for IoT companies, as it is a more general strategy that can be performed in a company from any other sector.

5. Conclusions, limitations and future research

5.1 Conclusions

This work contributed for the academic literature regarding the study of business models for IoT companies, and at the same time, contributed for the increasing trend in studying business models not only as something static, but as dynamic concept that changes and evolves throughout time. The literature review was important not only to outline the different conceptions of the IoT paradigm, but also to abridge the diverse literature that encompass the BM and BM change and evolution topics.

The multiple case study allowed to closely analyse the BMs from four IoT based companies, in two distinct moments of their evolution: the beginning of their operations and at the time of the interview (more than 3 years after its beginning). This made possible to further elaborate a cross-comparison between models, using the building block factors mentioned in the literature. Following, the main changes and reasons were also summarized and explored, in order to sustain the findings and answer the research question.

It is evidenced that the business model is not something static, it changes and evolves over time, as there are always external and internal factors that can push other blocks of the business model to change and adapt. Being IoT a technological paradigm, those changes can occur faster, as evidenced in some of the companies analysed, where despite their young age, several changes already happened in their BMs.

The findings show that companies tend to change their BM, primarily influenced by a modification in their value proposition. This can be caused by external factors, such as costumers and key partners, but also by a change into the company's strategy. Another important factor that can lead the value proposition to change is the incorrect articulation between the technology and the value proposition itself, which is crucial for a BM successful implementation. Therefore, confirming what is generally argued in the literature, the value proposition is the most important building block of the BM for IoT companies, and it should not be overlooked by companies.

Moreover, the importance of the customer segments regarding the BM change is also evident in the results, as it was the second most significant change observed in the findings.

Generally, companies have to carefully align their value proposition with the costumer segment, in order to achieve the so-called product-market fit (Nerkar & Roberts, 2004), that is essential to the success of the BM. This appears to be confirmed in the results, as all of the changes observed between this two building blocks seem to be related to one another.

Another important driver of change observed, is the fact that companies, especially in the early stages of their existence, start with an incomplete BM that evolves and adapts over time, which results from a learning process and experience. As also sustained in the literature, the BMs different components can influence one another, as there is a need of fit between components in order the BM to work. For example, the inclusion of a new key activity might have to be considered the cost structure, and if necessary, a new revenue stream might be required to support it.

A few building block factors stand out in the analysis. For the value proposition, the most used were "getting the job done" and convenience/usability. This does not mean, however, that they can lead to success per se, as still they need to be correctly articulated with the other BM components. Nevertheless, these factors seem to be relevant enough for IoT-based companies, and they should be considered when designing the BM value proposition.

Similarly important, is the software development as a key activity, the changes to a segmented market, and the adoption of cloud computing as key resources by three of the companies. Changing to a segmented market, as referred previously, does not seem to be linked exclusively to IoT companies, but still can be considered as a natural step of evolution, as evidenced in the companies analysed. Software development is key for IoT-based companies, and is an activity that for obvious reasons, should be considered key from the beginning. Cloud computing seems to be an important change, as small companies start to grow, it seems advantageous to adopt in most cases, and should be considered also for IoT-based companies.

Finally, the results evidence that three out of four companies analysed, seem to have more alignment with the building blocks factors identified by Dijkman et al. (2015) on the current BM than they had in the initial BM. The company were the same number of building block factors is observed in both initial and current BM, is the one that most resembles the framework purposed by Dijkman et al. (2015), and it is also the company that shows less change. All of this sustains that this framework can be helpful to assist the design of IoT-

based companies' BMs. Furthermore, is also important for companies to understand the causes that can lead them to change, in order to be better prepared to adapt and evolved their BMs.

5.2 Limitations

This work concerns a number of limitations that need to be highlighted. Firstly, due to the small number of companies analyzed, it is not possible to deduct generalizations as there is no evidence that the findings observed can represent the whole IoT industry. Also, all companies studied are from the same country, which narrows the results to be from the same socio-economic context. Nevertheless, these are common problems of qualitative research, and were considered when selecting the methodology of this work that, on the other side, allowed a considerable degree of depth in the analysis carried out.

It is also worth noticing the fact that the results are based on the interviewees notion of their company BM. Since not only the current BM was explored, but also the initial one, some of the interviewees responses might not be accurate as their memory could struggle to describe the details from years ago. Furthermore, interviews are also subject to errors and different interpretation of the questions and answers on both sides, which can result in inaccuracies of the results. However, to minimize these inaccuracies the BM canvas, a well-known framework, was used to simplify data collection, minimize significant differences of BM conception among interviewees, and ensure better communication between the interviewees and the researcher performing the interview.

To summarize, this work does not provide a formula for IoT companies, but provides a picture of what changed and why it changed. Some building block factors, as previously explained, are more present on the current BM than they were initially, but that again does not prove that they are more or less relevant than others that can be observed in IoT companies, other than the ones observed in this work.

Although the limitations depicted above, I am confident that this dissertation provided useful results and a good understanding of the changes that occurred in the IoT-based BMs,

although these results are still only exploratory, and further research is needed under the topic of change an evolution on IoT BMs.

5.3 Future research

Considering the limitations explained previously, further research on the topic of the IoT BM change and evolution, should address a wider sample, in different economies, and in different sectors where IoT is applicable. Also, a quantitative research can be made, in order to achieve results that can be generalized.

Further research should also address how IoT differ from other technological companies, and if they change and evolve differently as well. Moreover, in order to better understand the dynamics of the BMs in IoT companies, future work should explore how changes in specifics building blocks, can directly influence the change in others blocks.

Finally, further exploration of the already existing IoT-based BM framework should be conducted, and research in other areas that concerns BMs dynamics, such as innovation, design and implementation, should be also carried out.

Appendix A

Questionnaire - IoT business model change

Company name:
Interviewee(s):
Position:

1 - Brief introduction of the company: what you do, in which sector? What is the age and size of the company?

2 - What was the initial business model?

2.1 – Value proposition
2.2 - Customers Segments
2.3 - Channels
2.4 - Customer Relationships
2.5 - revenue streams
2.6 - Key Resources
2.7 - Key Partners
2.8 - Key Activities
2.9 - Cost structures

3 - What is the current business model?

3.1 – Value proposition
3.2 - Customers Segments
3.3 - Channels
3.4 - Customer Relationships
3.5 - revenue streams
3.6 - Key Resources
3.7 - Key Partners
3.8 - Key Activities
3.9 - Cost structures

4 - What changed and why it changed?

Appendix B

	What Changed and why it changed?
Company A	"We realize that with our current market at the time, it was not possible to reach the growth needed to accomplish the company's objectives"; "at the same time, we saw the growing interest of the automotive industry for autonomous driving vehicles, data exchange between vehicles. We realize that made sense to approach this market and check if our base platform was interesting to fit new vehicles out of the factory"; "this is a bigger market, with less players, and more vacationed to this kind of technology", "we adapted our pitch to understand what this market (automotive) was looking for, and we are currently working with those companies to adapt our solution", "we want them to save costs, and also use our platform to build new functionalities and services"
Company B	"the market demands to create a relationship and provide support, so we needed to find a way to have a recurrent revenue";" using cloud computing we provide the solution to be convenient to the customers, plus we can protect the algorithm and reducing the customer need to have additional machines, which was going to increase the initial costs ";" we realized that the medical industry does not want to have products that are reusable multiple times, event thought they can be sanitized, if it is disposable it is better, so we follow the tendency to have the consumable products to be the less times usable possible"; "we understood that was easier to sell our product and service when we started pitching to the customers that all they needed was just a table to use it, as it is wireless, can be taken everywhere, as it is working with the cloud, so they can also access a web platform wee they can access all the info anytime"; " all of this came up when talking with the customers and understanding their needs"; "initially our focus was just to have better and faster results, which was not the need for all the different customers"; "other customers needed to keep a record of the patients (…) and we started to offer that as well"; "this different features became the selling points for the different markets"
Company C	"we started with the base concept that allowed (the initial product) that allowed to build new products above it, and we were always close to the scientific and technological organizations"; "we responded rapidly to the market, *going with the flow*"; "we needed to adapt our pitch to the investors"; "it was a logic evolution, from where we were *demand pulled* by the different customers and partners, as they asked us for different needs"; "although there were many products that could be developed, we had to consider the ones that were feasible within our costs structure, and compete for R&D funds"; " the introduction of the project services was a result of a need from the market" ; "in the future we want to keep investing on new products and R&D as it

	is our core capacity, and take advantage of the relationships we build with our market"
Company D	"the main problem was the value proposition that was never accomplished, using the GSM triangulation it failed to successfully track people as it promised, which resulted in the disinterest of the customers who stopped the funding", "the cost structure was not adequate, the number of employees was superior to the needs"; " the new technology is way superior and can accomplish the value proposition"; "the focus is not only shopping centers, but others segments that can have interest in this technology" "the introduction of one time consultancy projects is something desirable as it is time limited and offer an extra opportunity for income"

Appendix C

BM Cross-comparison by building block factors

	Key factors	Company A		Company B		Company C		Company D	
		Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM	Initial BM	Current BM
Value proposition	Newness	x	x					x	x
	Perfomance								
	Customization		x			x	x		
	"getting the job done"			x	x	x	x	x	x
	Design								
	Brand/Status								
	Price								
	Cost reduction	x	x	x	x				
	Risk reduction								
	Accessibility								
	Convenience/usability	x	x		x	x	x		
	Comfort					x	x		
	Possibility for updates								
Customer segments	Mass market		x						
	Niche Market	x		x	x	x		x	
	Segmented						x		x
	Multi sided platform								
Channels	Sales force	x	x	x	x			x	x
	Web sales	x				x	x		
	Own stores								
	Partner stores								
	Wholesaler								
Customer relationships	Personal assistance								
	Dedicated assistance	x	x	x	x	x	x		
	Self-service								
	Automated service								x
	Communities					x	x		
	Co-creation							x	x
Key Resources	Physical resources								
	Intellectual property		x	x	x				
	Employee capabilities	x	x	x	x	x	x		
	Financial recources								
	Software							x	x
	Relations					x	x		

Key Partners	Hardware producers					**x**	**x**		
	Software developers								
	Other suppliers								
	Data interpretation								
	Launching customers							**x**	
	Distributors					**x**	**x**		
	Logistics								
	Service partners	**x**	**x**						**x**
Key Activities	Customer development		**x**						
	Product development	**x**	**x**	**x**	**x**	**x**	**x**		
	Implementation; Service	**x**	**x**						
	Marketing; Sales								
	Platform development								
	Software development	**x**	**x**		**x**	**x**	**x**	**x**	**x**
	Partner management								
	Logistics								
Revenue streams	Asset sale								
	Usage fee								
	Subscription fees	**x**	**x**	**x**	**x**			**x**	**x**
	Lending/renting/leasing								
	Licensing								
	Brokerage fees								
	Advertising								
	Startup fees								
	Installation fees		**x**		**x**			**x**	**x**
Cost structures	Product development cost			**x**	**x**				
	IT cost	**x**	**x**		**x**				**x**
	Personnel cost	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
	Hardware/production cost	**x**							**x**
	Logistics cost								
	Marketing & sales cost							**x**	
	Total	16	18	11	15	15	15	12	14

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